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THE EFFECT OF PROLONGED ACCELERATION ON GAS EXCHANGE AND RESISTANCE OF RATS TO HYPOXIA

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ABSTRACT

The author investigates the effect of prolonged acceleration on gas exchange and resistance of rats to hypoxia. An automatic gas-exchange investigating stand is described. It is found that in rats subjected to an increased force of gravity the gas exchange was lower than in control rats. The resistance of rats to "fatal hypoxia" proved to be higher than that of control rats. The resistance of test rats to "fatal acceleration", however, was lower than that of the control rats.

Study of the combined effects of various aspects of space flight and /1* specifically the effects of acceleration and hypoxia is of great theoretical and practical importance in bioastronautics.

The testing unit for the automatic study of gas exchange which was designed for this experiment consisted of an air-tight chamber for small laboratory animals (rats). Carbon dioxide and water vapor were absorbed by chemical absorbents and oxygen was fed automatically from a cylinder as it was consumed by the animals. The amount of oxygen consumed by the animals could be judged by the actuation of a pressure relay which controlled the flow of oxygen into the chamber, or by the length of the intervals between actuations.

The testing unit provided the following possibilities: Maintaining a preset gas composition for a prolonged period of time or causing progressive hypoxia when nitrogen was fed to the chamber from the cylinder instead of the oxygen used by the animals;

Obtaining information on the dynamics of animal oxygen consumption;

Placing the testing unit on a centrifuge and in this way investigating the simultaneous (combined) effects of acceleration and one gas medium or another /2 (specifically, hypoxia). In this way it was also possible to obtain information remotely on the oxygen consumption of the animals, their condition (by television or by recording biocurrents), and also on the parameters of the gas medium in the chamber (pressure, temperature, humidity).

The following investigations were made using the testing unit described:

*Numbers given in the margin indicate the pagination in the original foreign text.

Gas exchange in rats due to the effects of prolonged acceleration;

Combined effects of acceleration and hypoxia;

Specific features of gas exchange and reaction to the combined effects of acceleration and hypoxia in rats raised under conditions of daily, prolonged (lasting many hours) effects of acceleration.

1. The investigation of gas exchange (oxygen consumption) in rats was conducted during prolonged (from 6 to 48 hours) rotation in a centrifuge at accelerations of 1.5-4 and 10 G. During this time the animals were in a normal gas medium and were not held in place.

The results of the tests showed that due to the effects of acceleration gas exchange was decreased and was equal on an average to 65-80% of the value obtained in control tests in which there were no effects due to acceleration. The impression is also created that with an increase in the intensity of the effects of acceleration the gas exchange decreased even further. However, the information which was obtained does not permit a final conclusion to be reached on the gradual dependence of the degree of gas exchange decrease on acceleration intensity.

2. In the tests on the combined effects of acceleration and hypoxia a /3 study was made of the resistance of rats to "fatal hypoxia" while subjected to the effects of acceleration. Conditions of hypoxia were created in the chamber by feeding nitrogen instead of oxygen into the chamber. The control tests of resistance to "fatal hypoxia" were set up without introducing the effects of acceleration.

It was found that when exposed to the effects of acceleration the resistance of the rats to "fatal hypoxia" decreased appreciably. This was judged from the following indicators: total life time of the rats under conditions of hypoxia was shortened, the quantity of oxygen consumed during this period of time decreased, and the quantity of oxygen in the chamber at the instant the last rat died, as a rule, was greater than that in the control tests. This effect was more pronounced as the intensity of acceleration became greater (Table 1).

Table 1.

Resistance of Rats to "Fatal Hypoxia" When Exposed to the Effects of Acceleration

Indicator of Resistance to Hypoxia	Without the Effects of Acceleration (Control tests)	Acceleration 4	10	18
Lifetime of last rat, min	157	80	91.5	46
Oxygen content at end of test, in%	4.0	4.75	5.15	7.7
Quantity of oxygen consumed, relative units	8	7	5.5	-

3. The specific features of gas exchange and the reaction to the combined /4
effects of acceleration and hypoxia were investigated in rats which prior to this for a period of 2—3 months had been subjected to daily rotation in a centrifuge (2—3 G) for a period lasting several hours (5—6). Earlier it was reported by us and other authors that raising animals under conditions where they were exposed to an increased force of gravity has a marked effect on the morphogenesis, vegetational, and animal functions, and also the reactivity of their organisms (refs. 1—3). The stand for the automatic investigation of gas exchange made it possible to obtain new data in this respect.

a. Gas exchange (oxygen consumption) was studied in 43 rats which were subjected to rotation daily and in 53 control animals.

The investigation showed that in rats which were subjected to an increased force of gravity the gas exchange was considerably less than in the control animals.

This occurred when the investigation of gas exchange was conducted without the effects of acceleration and when the force of acceleration was 4 and 10 G (Table 2). In these tests confirmation was obtained of the fact that during acceleration gas exchange is decreased somewhat.

The investigation conducted one to two months after the cessation of daily rotation already failed to reveal these features in the gas exchange of the test animals and this was interpreted as evidence of the transient nature of these changes.

Table 2. O_2 Consumption in Test and Control Rats (without the Effects of Acceleration and with the Effects of an Acceleration of 10 G) /5

Effects of acceleration	O_2 Consumption (liters/day/kg/weight)		Difference in Consumption O_2 in test and control animals	
	control	test	liters	% %
Without acceleration	69.4	60.6	8.8	12.7
Acceleration of 10 G	43	37.7	5.3	12.3

b. The resistance of test rats to "fatal hypoxia" proved to be higher than that of control rats. This can be judged from the lower oxygen content in the chamber at the end of the tests as well as from the longer time the test rats lived under conditions of hypoxia.

c. On the other hand, the resistance of the test rats to "fatal acceleration" was somewhat lower than that of the control rats, but with respect to resistance to "fatal hypoxia" when the force of acceleration was 4 G the test

rats did not differ from the control rats. Probably in this case both factors (greater resistance to hypoxia than in the control animals and less resistance to acceleration) have a mutually leveling influence on one another.

The results of the investigation into the gas exchange in animals experiencing the effects of acceleration in our opinion are of interest in reaching an understanding of the reactions of an organism to prolonged acceleration and in judging the specific features of the metabolism under changed gravitational conditions.

As has been pointed out above, gas exchange in rats were reduced to the effects of acceleration. /6

Moreover, gas exchange was reduced even without the effects of acceleration in those animals which, prior to this for a period of two to three months, had been subjected daily to several hours of rotation in a centrifuge. These animals also withstood hypoxia better than the control animals, however, contrary to expectations, their resistance to strong ("fatal") acceleration was no greater but even lower than that of the control animals.

It was shown by us previously that in animals subjected to the effects of rotation on a daily basis there were smaller amounts in the urine passed daily of total nitrogen Dische-positive substances, creatine, and creatinine (ref. 3). All this can be interpreted as evidence of the fact that metabolism and expenditure of energy under conditions of prolonged effects of acceleration take place at a lower, "more economical" level. There is even data available literature that due to the effects of acceleration small laboratory animals may fall into a state which is close to anabiosis.

Finally, it is no surprise that while the effects of acceleration are being experienced by rats their resistance to hypoxia decreases.

The study of combined effects of acceleration, hypoxia, and other factors involved in flight is a pressing problem requiring thorough and systematic study.

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